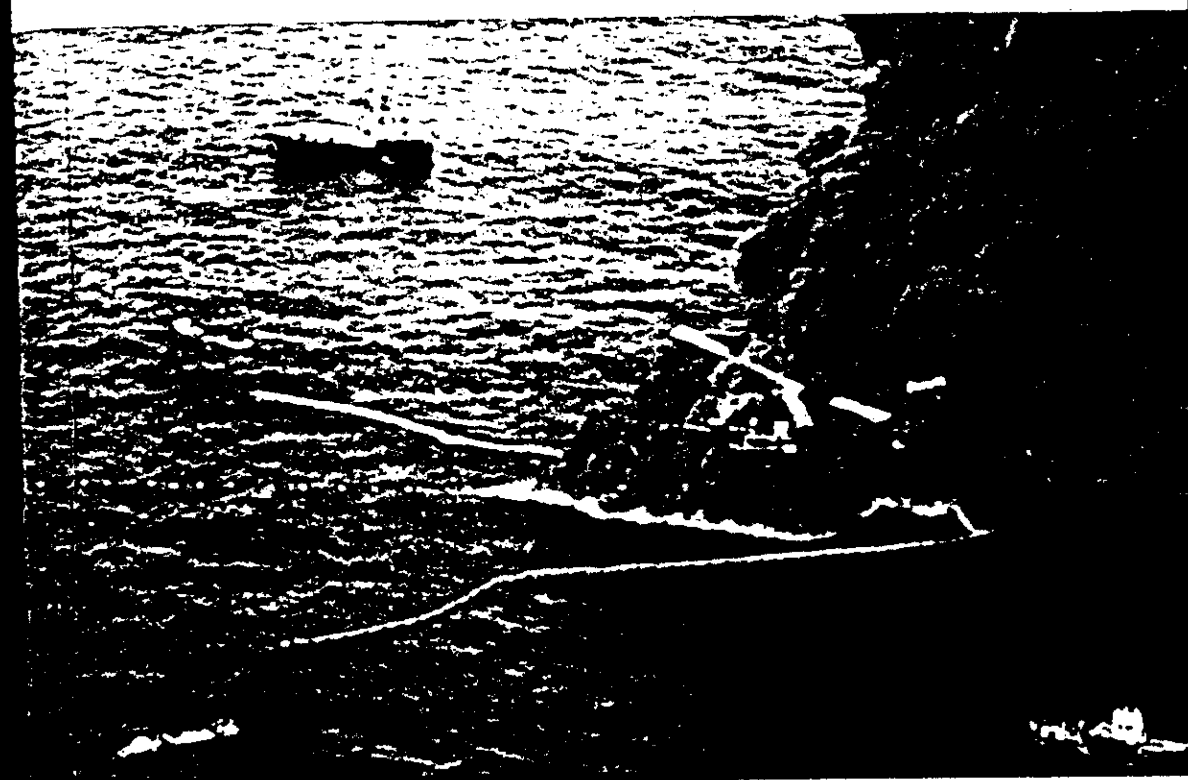
VOLUME 1

PROCEEDINGS OF THE SEVENTEENTH ARCTIC AND MARINE OIL SPILL PROGRAM (AMOP) TECHNICAL SEMINAR

COMPTE RENDU: 17ᵉ COLLOQUE TECHNIQUE DU PROGRAMME DE LUTTE CONTRE LES DÉVERSEMENTS D'HYDROCARBURES EN MER ET DANS L'ARCTIQUE (AMOP)



JUNE 8-10, 1994
VANCOUVER, BRITISH COLUMBIA

DU 8 AU 10 JUIN, 1994
VANCOUVER (COLOMBIE-BRITANNIQUE)

Environment Canada Environnement Canada

Canada

SAMPLING AND ANALYSIS IN THE FIELD: METHODOLOGIES USED BY THE EMERGENCIES SCIENCE DIVISION

Patrick G. Lambert, Ben G. Fieldhouse and Mervin F. Fingas
Emergencies Science Division, Environment Canada
Environmental Technology Centre
Ottawa, Ontario, Canada

Stephen J. Whiticar
Whiticar Scientific
Ottawa, Ontario, Canada

Edward J. Tennyson and Joe V. Mullin
U.S. Minerals Management Service
Herndon, Virginia, USA

Abstract

The importance of on-site analysis at a oil spill is to provide timely details on what potentially will happen to the oil and environment. The Emergencies Science Division, using experience gained from it's involvement in response to hazardous spills and from participation in a number of field experiments, has assembled several unique portable kits.

The surface sampling kit is designed to collect a sample for subsequent physical analysis and to measure the thickness of the oil on the water surface. The person-portable oil analysis kit is capable of measuring density, viscosity, water content, dispersant effectiveness, and emulsion breaking effectiveness. Apparatus used to determine these properties are common, low cost (<$1000) laboratory equipment. The case and contents weigh less than 12 kg (26 lbs) and does not contain any hazardous chemical reagents. The results obtained using the kit's methods are compared to laboratory techniques. Since its completion in 1992 Environment Canada's Portable Field Kit has been used regularly in the field. A critique of its performance and a description of any revisions is addressed. As well, a brief description is given of additional portable analytical equipment which could be used at a oil spill.

This paper will discuss the development of a surface sampling kit, a person-portable oil analysis kit, and an update of recent modifications to Environment Canada's Portable Field Kit.

Introduction

During a oil spill the circumstances surrounding the state of the spilled material are continuously changing forcing on-scene decision-makers to assess the situation quickly in order to optimize countermeasures. Consequently, there is a requirement for immediate information on the fate and behaviour of the oil. Environment Canada has been actively involved in the development of field portable methods and instrumentation for on-site analysis at a oil spill. Participation by the Emergencies Science Division in several field trials such as the 1992 mesoscale in-situ oil fires (Walton et al., 1993), the 1993 Airborne Oil-Spill Sensor Test Program (Brown et al., 1994) and the 1993 Newfoundland Offshore Burn Experiment (Fingas et at., 1994) has provided an opportunity to develop and test various ground truthing methodologies and apparatuses under field conditions. Techniques used successfully during these field trials have been assembled into emergency oil-spill response kits.

The objective of this project was to evaluate existing portable equipment and develop additional field kits which could be taken to a spill site and used to obtain information on the properties of the oil.

Methodologies and Equipment Selected for Kits

Surface Sampling Kit

Difficulties that are often underestimated during oil spills are the ones associated with the basic task of collecting oil samples from the water surface and/or carrying out measurements on the slick.

In order to facilitate the collection of the material a surface sampling kit was assembled. This kit contains the equipment necessary to collect oil from the water surface for subsequent physical analysis and to measure the thickness of oil on water. The sample collection apparatus was first developed for Environment Canada's Portable Field kit. Since it was initially reported (Lambert et al., 1991) the nets and telescopic pole in the kit have been replaced with commercially available ones supplied from a manufacturer of swimming pool equipment (Rainbow Plastics - California, U.S.A.). The nets are constructed of nylon as opposed to polypropylene/Teflon and come in several mesh sizes. The change in the net's construction material and the fact that both the net and pole are easily attainable reduces the cost of the apparatus significantly to the point were they can be considered consumable items. A sampling funnel was also developed for collecting low viscosity samples. This funnel is made of Tedlar and is equipped with a drain spout to remove excess water.

An extensive literature search of current methods and instruments for measuring oil thickness was undertaken. This lead to the evaluation in the laboratory of two commercially available instruments. One, a cylindrical tube with a ball valve, was constructed of materials which could not withstand repeated use. The second instrument was a interface meter common in the water well industry. It contains a probe with infrared refraction to detect liquids and conductivity to distinguish water (Solinst, 1993). Testing under simulated ocean conditions showed that the meter was not capable of consistently finding the oil/water interface, thus thickness results were highly variable. For all of these reasons both instruments were rejected.

Several techniques and apparatus have been evaluated over the past 20 years for measuring the thickness of oil on water at a spill. These range from visual estimation of thickness from the colour of the oil (Follum, 1989; Goodman, 1989; Schriel, 1989) to apparatus which collect a measurable volume of oil from a defined area (Belore, 1982; Malaczynski, 1983; Donney, 1992). Although limitations exist for each one of these approaches they remain the most commonly used and cost effective procedures.

During the course of our studies four methods were evaluated for measuring the thickness of oil on water. The following is a brief description of what they were and how they operate:

- A metal, cookie-cutter type sampler with a screen back was constructed. The apparatus has a known surface area and contains a polypropylene sorbent pad (3M Canada Inc. - London, Ontario) which was used to absorb the oil from the water surface. The volume of oil absorbed and the area of the sampler were used to calculate the thickness. The sampler and sorbent were attached to a telescopic pole and operated manually.
- A Teflon standard water bailer, which can be fastened to a telescopic pole and that collects and entraps a representative sample of the oil and water was also tested. When the oil layer separates from the water the thickness of the oil is measured.
- Under laboratory conditions the thickness of a oil layer can be calculated from the volume of oil discharged and surface area of a oil layer. During field tests, where known volumes of oil were placed in test tanks, the surface area of the oil was measured. The thickness was calculated from the known volume and measured surface area of the oil.
- Aerial and sea level photography were used to record the colour of the oil on the water surface. The colour of the oil is related to its thickness. A description of the colour and their respective thickness can be found in the references Follum, Goodman and Schriel, 1989.

Laboratory and field trials showed no that method was superior under all conditions. Instead they tend to complement each other. With the exception of aerial photography the surface sampling kit contains equipment necessary for measuring oil thickness via any of the aforementioned methods. Recommendations are given as to which method would be more affective under specific spill conditions. The equipment is similar to those developed previously but has been modified so they can be hand operated by one or two people stationed on a small surface boat. A list of the thickness measuring equipment is as follows: telescopic poles, wood frame, sorbent sheets, metal or Teflon storage containers, a customized Teflon standard water bailer, micrometer, and 35 mm colour camera.

Person-Portable Field Kit

A interest remains on the part of first response personnel in developing a compact kit which would provide general information on the properties of the oil while on site. The person-portable kit would be able to measure parameters such as density, viscosity, water content, dispersibilty of the oil, and the effectiveness of emulsion breaking solvents. The criteria for the kit were as follows:

- The complete kit should fit in a single case which can be easily carried by one person. It's size, shape, and contents should allow for it to be shipped by common modes of transport without having to meet transportation of dangerous goods regulations;
- The kit would require little if any maintenance and be ready-to-go without any preparation;

• Results are produced on site within a few hours of collecting the samples and are within defined limits of accuracy and reproducibility.

Procedures developed for the five physical measurements defined above and some of the alternative methods evaluated are briefly described here.

The density is determined by measuring the weight of a fixed volume of sample. A hand-held, battery-powered Acculab balance is used. This balance is capable of measuring weights to one tenth of a gram. Disposable syringes (1 mL or 10 mL volume) are used to obtain a precise sample volume. Both 1 mL and 10 mL syringes were examined to determine which volume provided more accurate and reproducible data. The 1 mL syringe requires less sample and the density of the sample can be read directly from the display. On the other hand the 10 mL syringe provides results with more significant figures, however the density must be calculated from the displayed weight (grams) divided by the volume (10 mL) of the sample. The precision required for the density results would dictate the size of syringe used.

Viscosity measurements are performed by recording the time required for the sample to flow through a Kreb viscosity cup. Two Kreb cups are included, one for fast flowing samples (low viscosity) and a second cup for slow flowing liquids (high viscosity). Time versus kinematic viscosity (centistoke, cSt) graphs have been prepared from commercially available standard viscosity solutions and are used to ascertain the viscosity of a sample. An alternative method investigated was to look for a mathematical relationship between the density and viscosity of oils. A literature review and laboratory work were unsuccessful at finding a practical equation for field use.

Two techniques were examined to determine the water content of a water-in-oil emulsion. The first method was to mathematically calculate the water content of a emulsion using the density values of the emulsion, salt water (3% salt by weight) and the crude oil. Five distinct emulsions were evaluated and their respective, calculated water contents were compared to water contents measured in the laboratory. Preliminary results were promising but a laboratory grade density meter capable of measuring density to three decimal places is required. The second means, a solvent extraction procedure, was chosen. A known volume of emulsion (10 mL) is placed in a separatory funnel and then broken using a solvent such as dichloromethane, acetone, or commercial emulsion breakers Vytak DM and Alcopol. After the oil and water layers have separated their volumes are measured and these numbers are used in conjunction with the initial emulsion volume to calculate the water content as a volume percent. Teflon separatory funnels and polypropylene measuring cylinders are included in the kit. The solvent Vytak DM was chosen as it is not hazardous and does not require special provisions for transport.

The person-portable kit contains a simplified version of the dispersibility test developed for the Portable Field Kit. Oil premixed with dispersant (25:1 oil to dispersant ratio) and non-treated oil are placed respectively in two Teflon separatory funnels containing sea water (1200:1 water to oil ratio). The contents of the separatory funnels are shaken for 1 minute and then allowed to settle for 10 minutes. To acquire a qualitative result the colour of the aqueous layer of the dispersant treated oil is visually compared to the colour of the aqueous layer of a non-treated sample.

The procedure and apparatus for the emulsion breaking effectiveness test are similar to the aforementioned water content test . The water to emulsion (10:1) and emulsion to emulsion breaker (100:1) ratios stipulated in the kit's procedure are the same as those presently used in the laboratory test under development by Environment Canada (Fingas et al., 1993). There are two notable differences between the water content procedure and the emulsion breaking effectiveness procedure. First, the emulsion is placed on the surface of sea water and then extracted with solvent. This step is included so that the effectiveness results can take into account the aqueous solubility of the emulsion breaking solvents. Secondly, the result is reported as the volume of water removed from the emulsion and not the water content of the emulsion. The effectiveness result is calculated by measuring the difference between the final water volume and the initial volume of water placed in the separatory funnel.

Portable Field Kit

The Portable Field Kit was designed to perform on-site analysis at a oil spill. Methods used in the kit are based on standard analytical techniques and produce laboratory grade results. Initial construction of the Portable Field Kit has been reported by Lambert et al., 1992. Recent work has involved the establishment of a maintenance and calibration timetable as well as the evaluation of the kit in the field and a comparison of the field results to those from laboratory analysis. The methods employed by the kit are based on standard laboratory procedures (ASTM, 1989) hence, state-of-the-art electronic equipment and chemical reagents are contained in the kit. Like all analytical laboratory apparatus the equipment and reagents must be maintained in a suitable condition to ensure they function properly. A program was set up with two objectives: to determine how much time could pass between the calibration of the instruments and the point at which they no longer operated within normal parameters, and secondly to establish the shelf-life of the kit's reagents.

As the need for information at a oil spill increases so too does the availability of methodologies and equipment . Environment Canada is continuously evaluating portable equipment which are suitable for oil spill response. One of the most common questions is the effect the spill will have on water or soil quality. Some of the lower molecular weight hydrocarbon compounds in oil such as benzene, toluene, ethylbenzene and xylenes can have adverse affects on the environment. There are several types of portable equipment presently available for measuring the amount of hydrocarbons in the environment. These include; colour tests, immunoassay techniques, gas chromatographic analysis and fluorometric and infrared spectroscopy. A fixed wavelength infrared spectrophotometer (Buck Scientific oil-in-water analyzer, model HC-404) has been added to the Portable Field Kit. This ruggedly constructed instrument weighs 9 kg (20 lbs.), utilizes a standard method of analysis and is capable of digitally displaying results in % transmittance, absorbance or concentration. The kit's procedure is similar to United States Environmental Protection Agency Method 418.1, "Total Recoverable Petroleum Hydrocarbons". The four alternative methodologies will be discussed in greater detail in future Environment Canada reports.

Results

Surface Sampling Kit

The sample collection apparatus has been thoroughly tested in the laboratory and used successfully in the field to obtain a variety of samples ranging from low viscosity crude oil to burn residue having the consistency of tar.

Laboratory tank tests of the sorbent pad sampler were carried out to evaluate the ability of a sorbent to measure the thickness of a oil layer and to determine the thickness at which a single pad reached it's oil absorption capacity. Alberta Sweet Mixed Blend (ASMB) crude oil was used as the test oil. Successive experiments had predetermined thicknesses ranging from 0.2 mm to 3.0 mm. The sorbent pads consistently gave results to within +/-0.1 mm of the predetermined values. A thickness value of 2 mm was calculated as the upper limit for a single pad. In order to simplify the procedure for field use the volume of oil absorbed was calculated from the difference in weight between the soiled and oil-free sorbent divided by the density of the oil. Future work will involve a comparison between this method of measuring the volume of oil absorbed and results from a extraction and spectroscopic analysis procedure.

A sorbent pad sampling apparatus was used to measure the thickness of the oil during the recent remote sensing field trials (Brown et al. 1994). The sampler consisted of a sorbent pad fastened in a 31cm x 31cm steel frame. The apparatus performed satisfactorily however the results were affected by environmental conditions. Wind herded the oil to a confined area causing the thickness of the oil layer to exceed the 2 mm capability of the sorbent and after collecting several samples the apparatus became soiled to the point that it no longer could be cleaned properly. Taking these difficulties into consideration the apparatus was modified for the Newfoundland Offshore Burn Experiment (NOBE). The metal sampler frame was removed and the size of the sorbent was increased to 1 m by 2 m. At both ends of the sorbent pad Velcro was used to attach the sorbent to a wood board which in turn was connected to the telescopic pole. These changes provided certain advantages. The new sampling apparatus was lighter than the metal frame predecessor and was better suited to withstand ocean conditions such as swells. The purpose of increasing the size of the sorbent was to minimize the error caused by absorption of oil along the side of the sorbent. This apparatus was used successfully during the NOBE burn to measure the amount of oil on the water surface behind the fire and row booms.

Initial laboratory and field trials with the bailer indicated that oil was lost to the surfaces of the apparatus generating poor measurements. To eliminate this problem two changes were incorporated, one to the sampling procedure, the other to the equipment. Through increasing the sampling rate and modifying the bailer by attaching a funnel to the base of the column, the volume of oil entering the bailer was raised and the oil had less opportunity to adhere to the surfaces. Thereby any effect the loss of oil would have on the measurements was minimized. Laboratory tank tests were performed with Alberta Sweet Mixed Blend crude oil (weathered 10% by weight) and the thickness of the oil layer ranged from 1 mm to 25 mm. The apparatus worked best for oil layers >10 mm. During the Newfoundland Offshore Burn Experiment this apparatus was successful in measuring the thickness of the oil at the apex of the fire boom.

The third technique, measuring the area of the slick then using the area and volume of oil discharged to calculate the thickness, was field tested during the previously mentioned remote sensing trials. Variations in wind speed and direction had a large effect on the size and shape of the oil layer which in turn hampered measurements of the oil slicks area.

Although several different thickness measuring techniques were evaluated during the remote sensing field test, the differences in the sampling procedures and sampling time made comparison of results between various thickness measuring techniques difficult.

Aerial and sea level photography were used to look for possible fugitive patches of oil during the NOBE trials. This was a backup method to determine the amount of oil present on the water surface. No oil was detected on the water surface either visually or through the use of surface sampling means.

Overall, the following recommendations can be made for the various techniques:

- Sorbent pad methods are best suited during calm water conditions when the oil layer is <2 mm. Results are not greatly affected by the type of support used to hold the sorbent in place, however the size and shape of the apparatus do affect it's handling characteristics.
- A bailer works well for thick oil slicks and is not affected by sea conditions.
- Sea level photography and aerial photography are valuable complimentary methods to both surface sampling procedures and should be used in conjunction with them. Nevertheless the apparent colour of the oil can be affected by weather conditions.
- Calculating thickness from the area of the slick and the volume of oil discharged is subject to numerous errors. The method is very time dependent and difficult to accomplish when the measurements have to be made by personnel at ground or sea level.

Person-Portable Oil Analysis Kit

The evaluation of the apparatuses used to measure the density of the oil was carried out in the laboratory at 15°C. Four samples with varying properties were selected for the test. These were deionized water, Alberta Sweet Mixed Blend crude oil (ASMB), Hydraulic Fluid Esso XD3-10 (Lube), and a water-in-oil emulsion (70% water by weight) composed of Arabian Medium crude oil and salt water (3% salt by weight). The person-portable field kit provided density values which were similar to Portable Field Kit and laboratory data.

The viscosity procedures were evaluated using several Newtonian crude oils (Mousse Mix crude oil is a 1:1 mixture of Alberta Sweet Mixed Blend crude oil and Bunker C oil) and a non-Newtonian water-in-oil emulsion (89% water by weight) of Sockeye crude oil and salt water (3% salt by weight). Data for the Newtonian solutions was satisfactory, however, the high yield point of the emulsion resulted in inconclusive measurements which in turn implies a limit on the effectiveness of this method for determining the viscosity of water-in-oil emulsions (non-Newtonian samples). Table 1 presents data comparing density and viscosity results from laboratory analysis and both field kits.

Table 1: Person-Portable Field Kit, Portable Field Kit , and Laboratory Results

Test	Sample	Laboratory Value	Portable Field Kit Results	Person Portable Field Kit Results
Density (15 °C) (g/mL)	Deionized water	0.9989	0.999	0.98(10 mL syringe) 1.0(1 mL syringe)
	ASMB	0.839	0.834	0.81(10 mL syringe) 0.8(1 mL syringe)
	Lube	0.8727	0.874	0.84(10 mL syringe) 0.9(1 mL syringe)
	Water-in-oil emulsion	not measured	1.038	0.83(10 mL syringe) 1.1(1 mL syringe)
Viscosity (cSt)	ASMB	8(15 °C)	34(22 °C)	16(22 °C)
	Lube	117(15 °C)	88(21 °C)	72(22 °C)
	Mouse Mix	48(15 °C)	33(22 °C)	41(22 °C)
	Water-in-oil emulsion	50,000(1 s^{-1}) 13,000(5 s^{-1}) (15 °C)	8500(22 s^{-1}) (22 °C)	>150,000 (22 °C)

The solvent extraction technique, developed for measuring the water content of water-in-oil emulsions, was evaluated with several solvents in order to determine their relative ability to separate the oil and water into distinct layers. The solvents were acetone, dichloromethane, chloroform, carbon tetrachloride, and two commercial emulsion breakers Alcopol and Vytak DM. Each hydrocarbon solvent was initially combined with the salt water/ Sockeye crude oil emulsion in a 1:1 ratio. A 1:100 solvent to emulsion ratio was used for Alcopol and Vytak DM. The solvent to emulsion ratio, the number of extractions, and the time the layers were allowed to separate were varied in order to optimize the procedure for the field. All of the solvents were capable of breaking the emulsion and produced water content values ranging from 70% to 99% by volume (water content of the emulsion was 89% by volume using the Karl Fischer titration method). For the petroleum hydrocarbon solvents, increasing the solvent to emulsion ratio improved the separation of the layers. However, when the number of extractions was increased the water content results became less consistent and reproducible. This was due to the formation of a web-like third phase between the water and oil layers. Increasing the ratio of Alcopol or Vytak DM to emulsion reduced the water content results. The formation of a web-like phase and the decrease in effectiveness at higher ratios of surfactant to emulsion were also noted perviously by Fingas et al., 1993. Finally, a time of 15 minutes was selected as the time interval the layers required to separate.

During the development of the Portable Field Kit an extensive laboratory investigation of the dispersibility procedure was carried out. The dispersibility values obtained using the procedures developed for the kit were comparable to the dispersibility data from laboratory techniques (Lambert et al., 1992). The simplified procedure in the person-portable kit does not provide a numerical value for dispersant effectiveness, instead a qualitative result is obtained.

The emulsion breaking procedure was evaluated in the laboratory using the salt water/Sockeye water-in-oil emulsion and Vytak DM solvent. Specific water, emulsion, and solvent volumes as well as mixing times were established to improve the reproducibility and to simplify the emulsion breaking effectiveness calculations. Parameters employed are; water volume of 100 mL, emulsion volume of 10 mL, emulsion breaking solvent volume of 0.1 mL, and a mixing time of 5 minutes.

Environment Canada's Portable Field Kit

In order to maintain the Portable Field Kit in top condition for emergency response, periodical maintenance needs to be performed. During the past three years testing was carried out on the kit's equipment to determine the frequency with which it had to be maintained and to ascertain the shelf life of the solvents. A schedule was established in which the time between the maintenance of the equipment in the kit was gradually increased from monthly to once every eight months. The data from these tests displayed that each piece of apparatus required slightly different maintenance schedules. For example, the spectrophotometer required battery recharging approximately every 3 to 4 months, the viscometer approximately every 6 to 8 months while the power source for density meter has lasted for over two years. The shelf life of the solvents was primarily dependent on the temperature at which they were stored and the head space in the bottle. The Karl Fischer reagent, a methanol based solution, was the most susceptible to degradation. A partially filled bottle of Karl Fischer reagent stored at room temperature degraded beyond use in 4 to 8 months. A semi-annual maintenance and calibration program was put in place.

The oil samples listed in Table 2 were collected and analyzed at various field experiments. Alberta Sweet mixed Blend (ASMB), Hydraulic Fluid Esso XD3-10 oil(Lube), Mousse Mix oil (a 1:1 mixture of Alberta Sweet Mixed Blend crude oil and Bunker C oil), and Terra Nova crude oil were used during the Remote Sensing experiments of May 1993 in Petawawa, Ontario. NOBE crude oil refers to the Alberta Sweet Mixed Blend oil used for the Newfoundland Offshore Burn Experiment in August 1993 and finally, Louisiana crude oil was used during the Mobile, Alabama burn experiments of November 1992. Crude oil was collected at the start of each experiment and analyzed on site, then stored in appropriate containers at cool temperatures until they could be analyzed at the Environmental Technology Centre in Ottawa. Methods used in the Portable Field Kit are describe in Lambert et al., 1992, while the laboratory techniques employed are described in Whiticar et al., 1993.

The results obtained in the field for density, viscosity, and water content using the kit are in good agreement with the measurements from standard laboratory techniques. Procedures in the kit for the flash point test are set up as a flash/no flash test at environmental temperatures and 60 °C. Sixty degrees Celsius has been established as temperature differentiating flammable and combustible materials where a substance with a flash point less than 60 °C is considered flammable and more hazardous. The results from the two different flash point procedures show similar trends.

Table 2: Portable Field Kit Results versus Laboratory Results

Test	Oil Type	Field Result	Lab Result
Density (g/mL)	ASMB	0.849(22 °C)	0.8487(15 °C)
	Lube	0.871(20 °C)	0.8727(15 °C)
	Mousse Mix	0.891(20 °C)	0.9001(15 °C)
	Terra Nova	0.859(20 °C)	0.8624(15 °C)
	NOBE	0.839(23 °C)	0.8431(15 °C)
	Louisiana	0.863(21 °C)	0.8517(15 °C)
Viscosity(mPa·s)	ASMB	29(22 °C) (700 s $^{-1}$)	7(15 °C) (500 s $^{-1}$)
	Lube	77(21 °C) (400 s $^{-1}$)	102(15 °C) (400 s $^{-1}$)
	Mousse Mix	29(22 °C) (400 s $^{-1}$)	43(15 °C) (400 s $^{-1}$)
	Terra Nova	22(21 °C) (400 s $^{-1}$)	30(15 °C) (500 s $^{-1}$)
	NOBE	10(23 °C) (400 s $^{-1}$)	10(15 °C) (500 s $^{-1}$)
	Louisiana	9(21 °C) (400 s $^{-1}$)	8(15 °C) (500 s $^{-1}$)
Water Content (weight %)	ASMB	1.03	0
	Lube	0.23	0
	Mousse Mix	0.26	0.23
	Terra Nova	0.31	1.47
	NOBE	0.23	0.21
Flash Point(°C)	ASMB	<60	-9
	Lube	>60	>95
	Mousse Mix	>60	>60
	Terra Nova	<60	4
	NOBE	<17	-15

Summary and Conclusions

Individual test methods and equipment have been evaluated and incorporated into three field kits. The purpose of these kits is to provide a means to collect oil samples at a spill site and perform timely, on-site analysis. The instruments and procedures have been tested under laboratory and field conditions. An outline of the kits is as follows:

- Surface sampling kit - contains the equipment necessary to collect a oil sample from the water surface as well as measure the thickness or amount of oil-on-water.
- A person-portable oil analysis kit was developed. Instruments and procedures are described for measuring the density, viscosity, and water content of oil, dispersant effectiveness, and emulsion breaker effectiveness. The methods were tested in the laboratory under simulated field conditions and produced results comparable to those from laboratory analysis.
- Environment Canada's Portable Field Kit has been used extensively in the field since it's development in 1992. Lessons learned in the field have lead to some modifications of the equipment and procedures. A calibration and maintenance timetable has been established to ensure the kit functions properly. Additional test methods to determine the concentration of hydrocarbons in soil or water have been included. Results obtained in the field compare favourably to subsequent laboratory analysis.

These kits have been assembled and are ready-to-go should the need arise, however further refinements to the kits and efforts to expand analytical capabilities for the field are an on-going process.

References

American Society for Testing and Materials, *1989 Annual Book of ASTM Standards - Petroleum Products, Lubricants and Fossil Fuels*, Vol. 5.01 to 5.03, Philadelphia, 1989.

Belore, R., "A device for Measuring Oil Slick Thickness", *Spill Technology Newsletter*, 7(2), 1982, pp. 44-47.

Brown, C., Fruhwirth, M., Wang, Z., Lambert, P., Fingas, M., "Airborne Oil-Spill Sensor Test Program", *Proceedings of the 2nd Thematic Conference Remote Sensing for Marine and Coastal Environments*, New Orleans, Louisiana, 1994, pp. I-19 - I-34.

Donnay, E., Jacques, T., Hiernaux, G., Quaghebeur, D., *Samplex, Expérimentation de techniques de prélèvement dans les rejets d'hydrocarbures en mer*, RAPPORT FINAL MINISTERE DE LA SANTE PUBLIQUE ET DE L'ENVIRONNEMENT INSTITUT D'HYGIENE ET D'EPIDEMIOLOGIE (IHE), Bruxelles, Belgique, 1992.

Fingas, M., Fieldhouse, B., Bier, I., Conrad, D., Tennyson, E., "Development of a test for Water-in-Oil Emulsion Breakers", *Proceedings of the 16th Arctic and*

Marine Oil Spill Program Technical Seminar , Calgary, Alberta, 1993, pp. 909-954.

Fingas, M., Ackerman, F., Bissonnette, M., Li, K., Lambert, P., Wang, Z., Campagna, P., Boileau, P., Larouche, N., Jokuty, P., Nelson, R., Turpin, R., Trespalacios, M., Halley, G., Belanger, J., Vanderkooy, N., Tennyson, E., Aurand, D., Hiltrabrand, R., " The Newfoundland Offshore Burn Experiment - NOBE Preliminary Results Of Emission Measurement", *Proceedings of the 17th Arctic and Marine Oil Spill Program Technical Seminar*, Vancouver, British Columbia, 1994.

Follum, O., "Application of the Technology in Norway", *The Remote Sensing of Oil Slicks*, A. E. Lodge, Ed., The Institute of Petroleum, London, 1989, pp. 33-38.

Goodman, R., "Application of the Technology in North America", *The Remote Sensing of Oil Slicks*, A. E. Lodge, Ed., The Institute of Petroleum, London, 1989, pp. 39-66.

Lambert, P., Bobra, M., Fingas, M., Gould, J., Tennyson, E., "Development of a Portable Field Kit for Measuring Properties of Spilled Oil," *Proceedings of the 14th Arctic and Marine Oil Spill Program Technical Seminar*, Vancouver, British Columbia, 1991, pp. 73-85.

Lambert, P., Bobra, M., *Development of a Field Portable Oil Analytical Kit*, Environment Canada Report EE-134, Ottawa, Ontario, 1992.

Malaczynski, M., "A Device for Measuring the Thickness of an Oil-On-Water Layer",
Spill Technology Newsletter, 8(4), 1983, pp. 95-98.

Schriel, R., "Application of the Technology in Netherlands", *The Remote Sensing of Oil Slicks*, A. E. Lodge, Ed., The Institute of Petroleum, London, 1989, pp. 17-28.

Solinst #121 Interface Meter manual, available from Solinst Canada Ltd., The Williams Mill, 515 Main Street, Glen Williams, Ontario, L7G 3S9.

Walton, W., Evans, D., McGrattan, K., Baum, H., Twilley, W., Madrzykowski, D., Putorti, A., Rehm, R., Koseki, H., Tennyson, E., "In Situ Burning of Oil Spills: Mesoscale Experiments and Analysis", *Proceedings of the 16th Arctic and Marine Oil Spill Program Technical Seminar*, Calgary, Alberta, 1993, pp. 679-734

Whiticar, S., Bobra, M., Fingas, M., Jokuty, P., Liuzzo, P., Callaghan, S., Ackerman, F., Cao, J., *A Catalogue of Crude Oil and Oil Product Properties*, Environment Canada Report EE-144, Ottawa, Ontario, 1992.